ISSN 1229-8565 (print)　ISSN 2287-5190 (on-line)
한국지역사회생활과학회지　25(4) : 601~608, 2014
Korean J Community Living Sci　25(4) : 601~608, 2014
http://dx.doi.org/10.7856/kjcls.2014.25.4.601

느릅 분말을 첨가한 요구르트의 이화학적 및 관능적 품질 특성

안 정 좌†
중원대학교 한방식품바이오학과

Physicochemical, Microbial, and Sensory Properties of Yogurt with *Ulmus davidiana* var. *japonica* During Storage

Ahn, Joungjwa†
Dept. of Food Science and Technology, Jungwon University

ABSTRACT

This study evaluates changes in yogurt with *Ulmus davidiana* var. *japonica (U. davidiana)* in terms of its physicochemical, microbial, and sensory properties during storage. The pH value and mean microbial counts of this yogurt with 0.2 to 0.8% of *U. davidiana* added ranged from 4.1 to 4.3 and from 1.4 x 10^8 to 2.3 x 10^8 cfu/mL, respectively, during storage at 7oC for 16 d. In terms of its color, the L value was significantly higher in the control and *U. davidiana* yogurt 0.2 to 0.4% up to 4 d, than other yogurt samples, and the b value was influenced by the addition of *U. davidiana* over 0.6% throughout the storage. According to a sensory test, there was a significant difference in the yellowness score between *U. davidiana* yogurt and the control, but earthy, and bitterness, and viscosity scores were similar. Overall acceptability was not significantly influenced after 8 d of storage in all yogurt samples, including the control. According to these results, concentrations (0.2 and 0.4%) of *U. davidiana* yogurt had no significantly adverse effects on its physicochemical, microbial, and sensory properties.

Key words: *Ulmus davidiana* var. *japonica*, yogurt, physicochemical properties, sensory properties, shelf life

I. Introduction

Yogurt is an important fermented dairy products that contains all nutrients and probiotics which are consumed for many generations in various countries (Gobbetti et al. 2004; Ahn et al. 2012). Beneficial flora, such as the genera of *Bifidobacterium* or *Lactobacillus*, could inhibit the growth of pathogenic bacteria and decrease the level of carcinogenic

This work was supported by the Jungwon University Research Grants.
접수일: 2014년 11월 11일 심사일: 2014년 11월 12일 게재확정일: 2014년 12월 2일
†**Corresponding Author**: Ahn, Joungjwa　Tel: 82-43-830-8611
e-mail: jjahn@jwu.ac.kr

materials, which further improves the colonic environment (Rinne et al. 2005; Hsu et al. 2006). To increase the demand of yogurt, health beneficial yogurt should be focused and developed. In recent years, many different food ingredients including peanut spouts extract (Ahn et al. 2012), yam (Hsu et al. 2006), chitosan (Seo et al. 2011), and ginseng (Lee et al. 2013) have been formulated into yogurt formulations to improve the nutritional value.

Ulmus davidiana var. *japonica* (*U. davidiana*) also known as Chinese skullcap, is a deciduous tree and widely distributed in Korea and its bark stem and roots are consumed as a traditional medicine (Song et al. 2007) and a tea in Asia (Jung et al. 2008). Also, inner bark dried and grounded into powder is used as a thickening in soups or added to cereal flours when making bread (Jung et al. 2008). *U. davidiana* has been reputed to be effective against gastric cancer, gastroenteric disorders, granulating, eruption, edema, rheumatoid arthritis, hemorrhoids, and mastitis (Jung et al. 2008). Investigations of the phytochemical components of *U. davidiana* stem bark have resulted in the isolation of catechin and related compounds. Recently, it was reported that *U. davidiana* var. japonica have a strong anti-oxidative activity (Ahn & Park 2010). Some synthetic antioxidant compounds, such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are commonly used in process food. There is thought to be an inverse relationship between dietary intake of antioxidant-rich foods and the incidence of human disease (Rice-Evans et al. 1997; Kim et al. 2014).

Although *U. davidiana* has been revealed for various health benefits, addition of certain pharmaceutical plant like *U. davidiana* to the food is very limited. Therefore, the objective of the present study was to evaluate the physicochemical and sensory changes of the yogurt added with *U. davidiana* powder during storage.

II. Materials and Methods

Materials

Commercial *Ulmus davidiana* var. *japonica* (*U. davidiana*) powder was purchased from Kyungdong market (Seoul, Korea) and stored at 4°C until use. All chemicals were purchased from Sigma Chemicals Co. (St. Louis, MO, USA), and all solvents were of chromatographic grade.

Manufacture of yogurt added with *Ulmus davidiana* var. *japonica*

Milk containing 3.6% fat and 13.4% total solids was mixed with different amounts of *U. davidiana* powder (0.2, 0.4, 0.6, and 0.8%) and 3.7% (w/v) skim milk powder and blended with Lab-blender (Tops MS3040, Misung, Seoul, Korea) at 400 rpm for 5 min. Each batch was made with 10 L of milk (2 L per treatment) at lab-scale level. The milk was added with *U. davidiana* powder and pasteurized at 90°C for 10 min in a water bath. After cooling to 4°C, 0.02% commercial starter culture (Chr. Hansen, Pty. Ltd, Bayswater, Australia) containing *Lactobacillus bulgaricus*, *Streptococcus thermophilus*, and *Bifidobacterium bifidum* was added and fermented at 43°C for 6 h until the final pH was reached at 4.5. After fermentation, each yogurt sample was stored for 0, 4, 8, 12, and 16 d at 7°C in a refrigerator to evaluate the physicochemical and sensory properties. Each batch of yogurt was done in triplicate.

pH

The pH values of the *U. davidiana*-added yogurt samples were measured using a glass electrode pH meter (Orion 900A, Boston, MA, USA). All samples were measured in triplicate.

Microbial analysis

MRS agar (Difco Laboratories, Detroit, MI, USA) was used for lactic acid bacteria counting. One milliliter of yogurt sample was diluted with 9 mL of sterile peptone and water diluents. Subsequent dilution of each sample was plated in triplicate and incubated at 37°C for 48 h.

Viscosity

The viscosity of yogurt samples (100 mL) was measured after mixing for 5 min at room temperature using a Brookfield viscometer (Model LVDV I+ Version 3.0, Stonington, MA, USA) with a spindle No. 2 at 60 rpm. All samples were measured in triplicate.

Color measurement

Color values of yogurt sample added with *U. davidiana* were measured using a Hunter colorimeter (Minolta CT-310, Tokyo, Japan) after calibrating its original value with a standard plate (X=97.83, Y=81.58, Z=91.51). Measurement L, a, and b values were used as indicators of lightness, redness and yellowness, respectively.

Sensory analysis

The sensory evaluation was performed by 8-trained panelists. The intensities of yogurt yellowness, earthy, bitterness, viscosity were evaluated on a 5-point scale (1=very weak, 2=weak, 3=moderate, 4= strong and 5=very strong). Overall acceptability was also scored on a 5-point scale (1=dislike extremely, 2=dislike, 3=neither like nor dislike, 4=like and 5=like extremely). A randomized, balanced, completely block design was used for all samples.

Statistical analysis

All statistical analyses were performed using SAS version 9.0 (SAS Institute Inc. Vary. NC, USA). ANOVA was performed using the general linear models procedure to determine significant differences among the samples. Means were compared by using Duncan's multiple range test ($p<0.05$).

Ⅲ. Results and Discussion

pH

The pH changes in yogurt samples added with various concentrations (0.2, 0.4, 0.6, and 0.8%) of *Ulmus davidiana* var. *japonica* during 16 d of storage at 7°C are shown in Table 1. No difference was found with addition of *U. davidiana* at various levels into the yogurt at 0 d, however, the more addition of *U. davidiana* showed the more decrease during 16 d storage. All samples showed a same trend, which was a slight decrease or maintained up up 8 d and a sharp decrease thereafter up tp 16 d. Especially, the yogurt sample added with 0.6 and 0.8% *U. davidiana* powder showed the dramatic decrease after 8 d storage compared to others. The pH values of the yogurt samples were ranged from 4.1 to 4.5 as

Table 1. Changes in the pH of *Ulmus davidiana* var. *japonica* yogurt at 7℃ for 16 d.

Concentration (%)	Storage period (d)				
	0	4	8	12	16
0	4.5±0.01[a]	4.5±0.02[a]	4.5±0.05[a]	4.4±0.06[a]	4.3±0.02[a]
0.2	4.5±0.01[a]	4.5±0.02[a]	4.4±0.01[a]	4.4±0.02[a]	4.3±0.01[a]
0.4	4.5±0.01[a]	4.5±0.03[a]	4.4±0.02[a]	4.3±0.01[a]	4.3±0.01[a]
0.6	4.4±0.01[a]	4.4±0.03[a]	4.3±0.01[b]	4.2±0.01[b]	4.1±0.01[b]
0.8	4.4±0.02[a]	4.4±0.01[a]	4.3±0.01[b]	4.2±0.01[b]	4.1±0.01[b]

Values are in mean±SD (n=3).
Means within the same column with different letters show significant differences at *$p<0.05$ based on Duncan's multiple-range test.

reflective of the fresh state. Increasing the storage period from 1 to 16 d decreased the pH values from 4.5 to 4.1, indicating that the yogurt quality was acceptable during 16 d storage. Lower pH was most likely due to the higher production of lactic acid during the storage period of 16 d (Kim et al. 2011; Ahn et al. 2012). Sugars like lactose in milk can be hydrolyzed by microbial enzymes, which can be further metabolized into lactic acid (Kim et al. 2011). Ahn et al. (2012) also observed that addition of nanopowdered peanut sprouts decreased the pH values during the storage period. These results indicated that 0.2 and 0.4% *U. davidiana* powder addition did not result in any significant change in yogurt pH during 16 d storage.

Microbial counts

The changes in *L. bulgaricus, S. thermophilus,* and *B. bifidum* of *U. davidiana*-added yogurt are shown in Table 2. At 0 d, the concentrations of 0.2 and 0.4%-added yogurt samples significantly higher in lactic microbial counts compared with other groups ($p<0.05$) until 12 d storage. Especially, 0.8% addition of *U. davidiana* showed the dramatic decrease after 12 d storage.

Seo et al. (2009) indicated that increasing the concentration of chitosan powder from 0.1 to 0.7% resulted in a reduction of the mean microbial counts. The findings could be explained by the fact that chitosan has antimicrobial effects (Qi et al. 2004). Since *U. davidiana* has been widely used as a traditional medicine with antiviral and antibacterial properties (Song et al. 2007), the decrease of microbial counts in 0.6 and 0.8% *U. davidiana*-added yogurt samples was attributed to the antimicrobial activity of *U. davidiana*, especially with a high concentration in the present study.

Viscosity

The viscosity changes of yogurt samples added with various concentrations (0.2, 0.4, 0.6, and 0.8%) of *U. davidiana* during 16 d of storage at 7°C are shown in Fig. 1. At 0 d, the viscosity value was slightly different by the addition of *U. davidiana* powder. The control and 0.2%-added yogurt showed the dramatic increase up to 8 d, slightly decreased and maintained thereafter. However, other samples containing 0.4, 0.6, and 0.8% addition showed a decreasing trend up to 12 d and maintained thereafter. Higher the concentration *U. davidiana* powder addition to the yogurt lowered the viscosity value during 16 d storage period. Increasing the viscosity in control and 0.2%-added yogurt was most likely due to the production of viscous exopolysaccharides along with the lactic acid by microbes during the storage (Vijayendra et al. 2008). However, the addition of *U. davidiana* powder at high level (0.8%) showed the significantly lower viscosity value compared with the

Table 2. Changes in microbial counts of *Ulmus davidiana* var. *japonica* yogurt at 7℃ for 16 d.

Concentration (%)	Storage period (d)				
	0	4	8	12	16
0	$2.3x10^{8c}$	$2.4x10^{8bc}$	$2.3x10^{8d}$	$2.8x10^{8c}$	$2.3x10^{8a}$
0.2	$3.1x10^{8a}$	$3.0x10^{8a}$	$4.4x10^{8a}$	$3.5x10^{8a}$	$2.3x10^{8a}$
0.4	$2.7x10^{8b}$	$2.8x10^{8ab}$	$3.3x10^{8b}$	$3.1x10^{8b}$	$2.1x10^{8ab}$
0.6	$2.2x10^{8c}$	$2.1x10^{8c}$	$2.7x10^{8c}$	$2.1x10^{8d}$	$1.9x10^{8b}$
0.8	$2.2x10^{8c}$	$2.5x10^{8b}$	$2.8x10^{8c}$	$2.4x10^{8d}$	$1.4x10^{8c}$

Values are in mean±SD (n=3).
Means within the same column with different letters show significant differences at $^*p<0.05$ based on Duncan's multiple-range test.

others at all storage time ($p<0.05$) (Fig. 1). Antonov et al. (1996) postulated that casein in yogurt interacts with polysaccharide lead to increase in viscosity, but promoting phase separation (Amaya-Liano et al. 2008). Thus, addition of higher concentration of *U. davidiana* powder in yogurt may enhance the phase separation with lower viscosity during the storage. The present study indicated that there was a defect in yogurt viscosity with 0.8% and higher addition of *U. davidiana* powder, if the storage period to 4 d and longer.

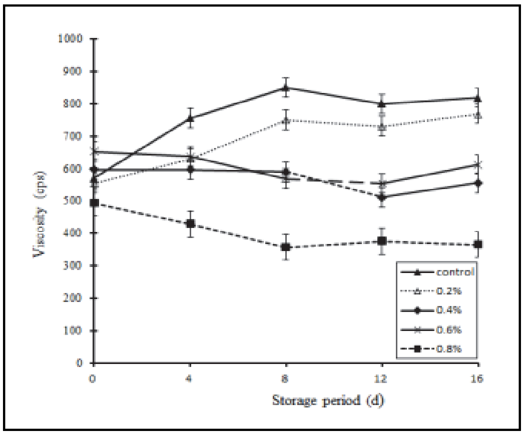

Fig. 1. Changes in the viscosity of *Ulmus davidiana* var. *japonica* yogurt at 7℃ for 16 d. Values are in mean±SD (n=3).

Color

The changes in color of *U. davidiana*-added yogurt samples stored at 7°C for 16 d are presented in Table 3. The L values of the yogurt-added with 0.6, and 0.8% of *U. davidiana* were significantly different from those of the yogurt-added with 0, 0.2, and 0.4% from 0 to 8 d storage ($p<0.05$). Increasing the concentration of *U. davidiana* addition in yogurt resulted in lower L value. The a value was found to be significantly higher in *U. davidiana*-added yogurt than in the control in all storage periods except for 0 d ($p<0.05$). Especially, over 0.6% addition resulted in a dramatic change in a value after 12 d. There was no difference in b value among in the control and 0.2 and 0.4% *U. davidiana*-added yoghurts throughout storage period ($p>0.05$). However, a significant decrease in b value was observed in 0.6 and 0.8% *U. davidiana*-added yoghurts, compared with in the control, 0.2, and 0.4% *U. davidiana*-added yoghurts, which mostly likely due to the yellow color of *U. davidiana.* Ahn et al. (2012) reported that the addition of nanopowdered peanut sprouts in yogurt greatly increased the b values during the increase storage period attributed by the light yellow color of the peanut sprouts. Some other researchers also reported that addition of apple or orange fiber in the yogurt increased the yellow color in the yogurt (Garcia-Perez et al. 2005). Therefore, these results indicated that there were considerable changes in over 0.6% *U. davidiana*-added yogurt during the 16 d storage in all color values.

Sensory evaluation

The sensory properties of *U. davidiana*-added yogurt stored at 7°C for 16 d are shown in Table 4. As we expected, the yellowness score increased with an increase concentrations of *U. davidiana* addition to the yogurt throughout storage periods. No difference was found in earthy flavor among all yogurt samples, and the earthy values becomes weaker with the extended storage in all samples ($p>0.05$). The bitterness score was not significantly different between *U. davidiana*-added yogurt and the control after 4 d storage ($p>0.05$) and a slightly higher score was shown in 0 d. This result in not accordance to other study, which has reported that addition of peanut sprout powder increased the bitterness score in yogurt during the storage periods (Ahn et al. 2012). Viscosity score also was not affected by *U. davidiana* addition to the yogurt. Finally, adding *U. davidiana* powder into the yogurt samples did not significantly influence on the overall acceptability after 8 d storage and thereafter. Based on all the sensory data, it is indicated that 0.2 and

Table 3. Changes in the color of *Ulmus davidiana* var. *japonica* yogurt at 7℃ for 16 d.

Concentration (%)	Storage period (d)														
	0			4			8			12			16		
	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
0	81.8±1.3^{a}	-1.8±0.06^{a}	4.8±0.9^{b}	84.5±0.1^{a}	-2.3±0.05^{a}	5.3±0.1^{c}	83.4±0.2^{a}	-2.2±0.03^{a}	5.4±0.1^{d}	84.1±0.2^{a}	-2.2±0.06^{a}	5.2±0.1^{d}	83.7±0.2^{a}	-2.2±0.01^{a}	5.5±0.1^{c}
0.2	82.1±0.2^{a}	-1.8±0.01^{a}	5.5±0.2^{b}	83.6±0.4^{a}	-1.9±0.03^{b}	6.5±0.2^{a}	82.2±0.1^{b}	-1.7±0.01^{b}	6.1±0.1^{c}	83.3±0.7^{a}	-1.9±0.01^{a}	6.2±0.7^{a}	82.8±0.2^{b}	-1.9±0.02^{a}	6.3±0.1^{b}
0.4	81.3±0.7^{a}	-1.8±0.02^{a}	5.7±0.1^{b}	82.7±0.7^{a}	-1.9±0.35^{c}	6.4±0.1^{b}	81.1±0.2^{c}	-1.6±0.01^{c}	6.0±0.1^{c}	81.4±1.1^{b}	-1.7±0.03^{c}	5.9±0.2^{c}	81.4±0.1^{c}	-1.5±0.02^{c}	6.2±0.1^{b}
0.6	79.4±0.2^{c}	-1.7±0.01^{b}	7.0±0.1^{a}	77.0±1.7^{b}	-1.8±0.36^{c}	7.0±0.1^{a}	81.1±0.1^{c}	-1.4±0.02^{d}	6.6±0.1^{b}	81.4±0.3^{b}	-1.4±0.21^{d}	7.1±0.1^{b}	81.5±0.4^{c}	-1.1±0.03^{d}	7.3±0.1^{a}
0.8	72.3±0.3^{b}	-1.7±0.02^{b}	7.1±0.8^{a}	74.4±0.1^{c}	-1.9±0.21^{b}	7.1±0.1^{a}	80.6±0.3^{d}	-1.0±0.07^{e}	7.7±0.1^{a}	80.5±0.4^{c}	-0.9±0.08^{e}	7.6±0.2^{a}	80.5±0.1^{d}	-0.9±0.05^{e}	7.4±0.1^{a}

Values are in mean±SD (n=3).

Means within the same column with different letters show significant differences at *p<0.05 based on Duncan's multiple-range test.

Table 4. Sensory characteristics for *Ulmus davidiana* var. *japonica*-added yogurt at 7℃ for 16 d.

Storage period (d)	Concentration (%)	Yellowness	Earthy	Bitterness	Viscosity	Overall acceptability
0	0	2.8±0.6[b]	2.5±0.1[b]	3.1±0.3[c]	3.1±0.3[a]	2.9±0.6[a]
	0.2	2.8±0.8[b]	3.1±0.7[a]	2.9±1.3[c]	3.5±1.0[a]	2.9±1.4[a]
	0.4	2.9±1.2[b]	2.9±0.9[ab]	2.4±1.2[c]	3.1±1.3[a]	3.1±1.4[a]
	0.6	3.7±0.9[ab]	3.2±0.9[a]	3.9±0.7[b]	3.3±0.7[a]	3.0±1.2[a]
	0.8	3.9±0.9[a]	3.5±0.7[a]	4.4±0.7[a]	3.6±1.1[a]	2.6±1.3[a]
4	0	2.5±1.3[c]	2.3±0.8[a]	2.7±1.1[a]	3.3±0.8[a]	2.7±0.8[a]
	0.2	2.8±0.9[bc]	2.6±1.1[a]	3.1±1.1[a]	3.7±0.8[a]	2.5±0.7[a]
	0.4	3.3±1.1[ab]	2.4±0.8[a]	3.6±0.8[a]	2.0±0.8[b]	3.1±0.9[a]
	0.6	3.8±0.6[a]	2.8±1.0[a]	3.7±0.9[a]	2.6±0.7[b]	3.3±1.0[a]
	0.8	3.5±1.4[ab]	2.9±1.1[a]	3.4±1.0[a]	2.5±0.5[b]	2.5±0.9[a]
8	0	2.5±0.9[c]	2.3±0.9[a]	2.5±0.8[a]	3.1±0.4[a]	3.0±0.8[a]
	0.2	3.0±0.8[bc]	2.4±0.8[a]	3.2±0.6[a]	2.8±0.9[a]	3.0±0.5[a]
	0.4	3.2±0.9[b]	2.4±0.9[a]	3.2±0.9[a]	2.5±1.0[a]	3.0±0.7[a]
	0.6	3.6±0.7[a]	2.7±1.0[a]	3.3±0.8[a]	2.8±0.8[a]	2.9±0.5[a]
	0.8	3.8±0.9[a]	2.5±0.8[a]	3.4±1.0[a]	2.4±0.5[a]	2.7±1.1[a]
12	0	2.5±1.1[b]	2.1±0.7[a]	2.5±0.7[a]	2.3±0.8[a]	3.0±0.9[a]
	0.2	3.0±0.7[b]	2.4±1.0[a]	3.4±0.9[a]	2.7±0.8[a]	3.0±1.1[a]
	0.4	3.1±0.8[b]	2.4±1.0[a]	2.9±0.9[a]	2.4±0.8[a]	2.9±0.9[a]
	0.6	3.6±0.5[a]	2.6±0.9[a]	3.2±1.0[a]	3.0±0.9[a]	2.9±0.9[a]
	0.8	4.0±0.9[a]	2.1±0.8[a]	3.3±1.0[a]	2.3±0.9[a]	2.7±0.8[a]
16	0	2.0±1.4[c]	2.1±0.9[a]	2.6±1.1[a]	2.4±0.7[a]	3.1±0.9[a]
	0.2	3.1±0.6[b]	2.0±1.1[a]	3.3±1.1[a]	2.6±1.1[a]	3.0±1.1[a]
	0.4	3.1±0.7[b]	2.2±1.0[a]	2.6±0.7[a]	2.5±0.8[a]	3.2±0.9[a]
	0.6	3.6±0.5[b]	2.1±1.1[a]	3.6±1.1[a]	2.7±1.0[a]	2.7±1.1[a]
	0.8	4.4±0.7[a]	2.5±1.0[a]	3.2±1.0[a]	2.1±1.1[a]	2.7±1.2[a]

Means within the same column with different letters show significant differences at *p<0.05 based on Duncan's multiple-range test.

0.4% of *U. davidiana*-addition could be applicable in yogurt manufacture without any changes in sensory properties.

Ⅳ. Summary and Conclusion

The present study was designed to investigate the effect of *Ulmus davidiana* var. *japonica* addition on the physicochemical, microbial, and sensory properties of yogurt during 16 d storage period. The data on pH, viscosity, color, and microbial counts and sensory analysis obtained from the present study indicated that concentration of 0.2 and 0.4% *U. davidiana* could be used as a novel ingredient in yogurt manufacture. On the view point of the health aspects, the *U. davidiana* powder added yogurt may act as a functional yogurt which can improve gastric disorder. Also, earlier study showed the extract of *U. davidiana* var. *japonica* is an effective antioxidant and has protective effect of DNA damage against oxidative stress (Ahn & Park 2010). Therefore, the production of yogurt that incorporates *U. davidiana* var. *japonica* can broaden the utilization of other traditional medicine, and the products can be regarded as possible health-promoting food.

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